Grade Level/Course:
Grade 8 / Physical Science

Lesson/Unit Plan Name:
Insulation and Heat Transfer

Rationale/Lesson Abstract:
This lesson and activity will allow students the opportunity to design, test, and improve a cup to prevent heat loss. It serves as an introduction to conductors and insulators, energy transfer, direction of heat flow, motion of particles, and engineering and design principles.

Timeframe:
1 class period

Standard(s):

MS.Energy

MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3)

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4)

PS3.B: Conservation of Energy and Energy Transfer

- Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)

ETS1.A: Defining and Delimiting an Engineering Problem

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3)

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)

Crosscutting Concepts

Energy and Matter

- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS- PS3-3)

Articulation across grade-bands: **4.PS3.B** (MS-PS3-1),(MS-PS3-3); **4.PS3.C** (MS-PS3-4),(MS-PS3-5); **HS.PS1.B** (MS-PS3-4); **HS.PS2.B** (MS-PS3-2); **HS.PS3.A** (MS-PS3-1),(MS-PS3- 4),(MS-PS3-5); **HS.PS3.B** (MS-PS3-1),(MS-PS3-2),(MS-PS3-3),(MS-PS3-4),(MS-PS3-5); **HS.PS3.C** (MS-PS3-2)

Instructional Resources/Materials:

For Warm up
Actual objects in class or per group, or photos of four items to compare, e.g.:

- a metal bar
- a fleece glove
- a plastic block
- a cup of water

For Activity
Per group:

- 10 oz. of hot water
- 1 paper cup (able to contain hot water)
- thermometer
- Suggested materials for insulation challenge:
  (or replace with what you have, or use other ideas!)
  - masking tape
  - yarn
  - Styrofoam
  - bubble wrap
  - fleece/fabric
  - tissue paper
  - duct tape
  - aluminum foil
  - sand
  - paper
  - cotton balls
  - packing material

Activity/Lesson:

Warm Up
Place four items to compare,
e.g. metal, fleece, water, plastic.
"Arrange these from coldest to warmest"

Allow students time to discuss in pairs, and write response.
Students typically choose water and metal as "cold" and fleece as "warm".

Discuss now, or save for later in lesson:
- All the items, measured with a thermometer, are actually **equal to room temperature**. However, our bodies—or our skin—perceive them to be different based on the ability of the material to conduct heat. Heat passes easily through metals and through water, so we perceive those items as "cold" as the heat leaves our body. Plastic and fleece are better "insulators", which means the heat from our body does not leave so quickly. We don't perceive as well the loss of heat.

Investigation

Introduce the concept of heat loss. Examples may include a hot cup of water cooling off. These questions can be answered now in the lesson, or better, later after the investigation.

- What happens to hot water as time goes by? *It cools off (or loses heat).*
- Why does hot water get colder? *Heat travels from higher to lower.*
- Where does the heat go? *Into the room.*
- Can this be prevented? *The process can be slowed down using "insulators", or "insulation".*

Students now will design modifications to a paper cup to help prevent heat loss. Have several materials available for students to choose from (listed above).

Students should work in pairs to plan, design and sketch their prototype, and then make the physical modifications to the cup.

Suggested constraints:

- 10-15 minutes to design, sketch, and construct insulated cup
- Including modifications, the cup must fit in one hand, and be portable
- The top must be open, and you must be able, in theory, to drink from the rim of the cup
- You may only use three materials in your design to modify the cup

Hot water should then **carefully** be distributed to the students into their modified cups. Students should record the starting temperature, and the timer should begin. After 10 minutes, students should record the final temperature, and share their results for a class data table.

To discuss as a class:

- What designs and materials were most effective in reducing the rate of heat loss? (Which cups remained at the highest temperatures?)
- What materials make the best insulators?

Extend, either by discussion, or if time permits students can continue:

- Using the data provided by the class, and the experience of a first trial, what refinements would you make?
- What if you could use four materials?
- What if you could only use two?

Explain:

Heat

- Heat is produced by the motion of particles
- Temperature is a measure of the average motion of particles
- Heat (energy) always travels from hotter regions to colder regions
- Some materials, like metals, are good conductors of heat
- Other materials, like nonmetals, wood, and plastic are poor conductors of heat, also known as “insulators”

Engineering

- Defined criteria and specific constraints lead to the likelihood of success in a solution.
- A solution needs to be tested, and then based on the results, modified again for improvement.

Assessment:

Exit Ticket

Show photos of common household items whose purpose it is either to conduct or insulate heat, e.g. a wooden spoon, a travel mug, an oven mitt.

“Describe how each of these items is used. When possible, use the words ‘heat’, ‘conductivity, ‘insulation” or related terms.”